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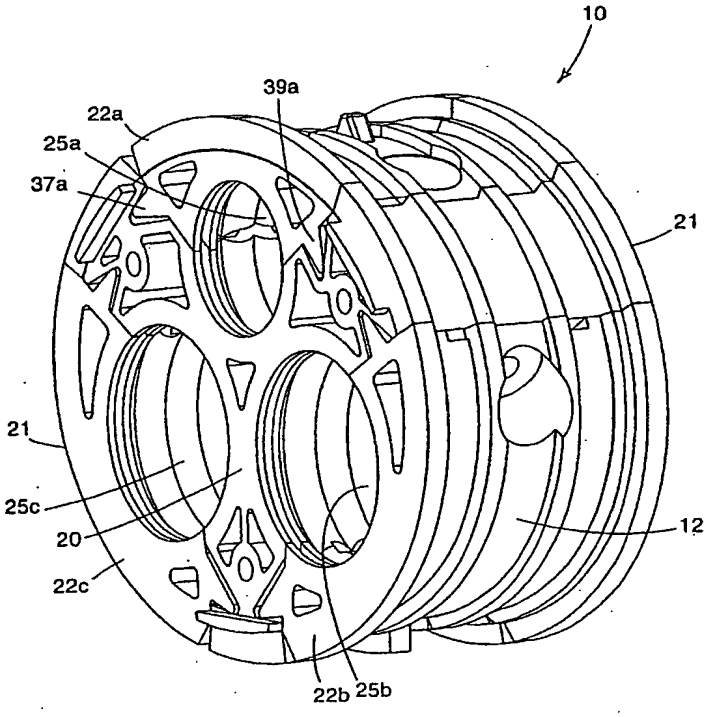
(54) Title: SEGMENTED END SEAL FOR A CLOSURE SUCH AS SPLICE CASE

(57) Abstract

An end seal (10) is provided for sealing the space between at least one cable and a closure such as a splice case. The end seal (10) includes a centrally located support structure (20) having a plurality of radially extending members (40, 42, 46) each defined by spaced, opposing end faces (21) and an outer peripheral surface. Each of the radially extending members (40, 42, 46) has first and second mating surfaces and a notch located in the first and second mating surfaces. The first and second mating surfaces are connected to, and extend between, the end faces of their respective radially extending members. The end seal (10) also includes a plurality of segments (22a, 22b, 22c) having spaced, opposing end faces. The plurality of segments each interlock with the support structure (20) so that each of the end faces of the segments extend in a common plane with one of the end faces of the support structure. Each segment (22a, 22b, 22c) includes an outer peripheral surface and first and second end surfaces connected to and extending between the end faces of the segment. The first and second end surfaces have first and second tabs (37a, 39a) extending respectively therefrom. The first and second tabs (37a, 39a) are insertable in first and second ones of the notches (52, 54) respectively located in adjacent ones of the radially extending members of the support structure (20). The first and second notches (52, 54), respectively, in a prescribed sequence so that the segment (22a) interlocks with the support structure (20). At least one aperture (25a) extends between the opposing end faces for receiving a cable. The aperture (25a) is formed, at least in part, from a semicylindrical surface located in one of the segments (22a).



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SEGMENTED END SEAL FOR A CLOSURE SUCH AS A SPLICE CASE

Field of the Invention

The present invention relates generally to a segmented end seal for cables entering a splice case, and in particular to a segmented end seal in which the cable-receiving segments readily interlock with a central support body with a minimum of additional hardware.

Background of the Invention

Two or more cables, such as telecommunications cables, must often be spliced together to extend or tap into a cable. The formation of a splice involves removal of the outer jacket and other layers of the cable to expose the individual conductors or optical fibers which are then individually connected to the conductors or fibers of another cable or cables. After the splice is formed, it must be protected from water and other vapors to prevent corrosion or a short circuit. For this purpose, the splice area is often enclosed in a splice case that is formed from two trough-like half shells with separate end plates or seals. Different end seals are used to accommodate different diameter cables and splice cases of different dimensions.

While end seals have been proposed which have many different designs and configurations, one disadvantage they have in common is that it is cumbersome and time-consuming to add or remove a cable. For example, U.S. 5,258,578 (Smith et al.) discloses an end seal that is adapted to seal the space between the cables and the splice case to restrict fluid transfer through the seal. The seal is formed from a body of an elastic, flexible material such as a gel having self-adhesive properties. The body comprises a core portion and a tail portion. The core portion has a shape corresponding to the ends of the splice case and includes cylindrical openings through which the cables extend. The openings are exposed at the outer peripheral surface of the core. The body of the seal also includes a tail portion that is integral with, and extends from, the surface of the core portion. The tail portion has a length sufficient to wrap about the outer peripheral surface of the core to cover all the cylindrical openings. The openings are generally smaller than the diameter of the cables to be placed therein so that the elastic core must expand for the openings to accommodate the cables. When wrapped around the core, the tail seals the portion of the cable between the core and the inside surface of the ends of the splice case. One limitation

of this end seal is that, whenever it is removed from a splice case, the seals formed between the core and the cables extending through the openings in the core are disturbed, and therefore the cables must be repositioned upon re-installation of the end seal.

Another proposed type of end seal is formed from two or more segments that mate with a centrally located support structure. End seals of this type are shown, for example, in U.S. 4,692,565 (Koht et al.). The segments contain one or more apertures for receiving a cable. When a cable must be added, removed or changed, it is thus only necessary to remove the segment containing the given cable without disturbing the remaining segments. However, the segments, which surround and abut the support structure, are not fastened to the support structure. Rather, the segments and the support structure are held together by the forces exerted upon them by the splice case itself. Accordingly, when one segment is removed from the splice case, the remaining segments and the support structure will not necessarily remain in place.

Another segmented end seal is disclosed in U.S. 5,825,961 (Wilkins et al.). A similar type of end seal is disclosed in a PSI Telecommunications Inc. catalog entitled "2-Type Closure System" (1990). In this type of end seal, the segments are secured to the support structure by a pair of bolts. While this arrangement prevents the individual components of the end seal from easily separating from one another, it makes it difficult to remove a single segment, since two bolts must be removed.

Another problem with many existing end seals is that they do not have a plane of symmetry, and are therefore not reversible. As a result, two different end seals must be made for use in a conventional splice tray, and these end seals cannot be used interchangeably. This adds to the manufacturing costs, and also complicates the use of these end seals in the field.

There is thus a need in the art for a segmented end seal in which the segments can be easily attached to, and removed from, the support body with a minimum of additional hardware, yet which can be adapted to provide a desired pressure distribution (e.g., an even pressure distribution) across a particular segment. There is also a need in the art for a segmented end seal in which the segments can be independently removed without disrupting the remaining segments or existing seals between the end seal and any cables inserted therein. There is further a need in the art for an end seal which has a plane of symmetry such that the end seal is reversible, and can be used for either side of a splice case.

These and other needs are met by the present invention, as hereinafter described.

Summary of the Invention

The present invention provides a segmented end seal in which the segments interlock with the support structure so that only a single fastener is needed to fix a given segment to the support structure. This result is achieved by providing the segments with tabs that are inserted into notches located in the support structure. The tabs are oriented with respect to one another such that they must be inserted and removed from the notches in a particular sequence. Typically, the tabs are oriented so as to provide an even distribution of pressure across the segment, but they can also be oriented so as to provide an unequal distribution of pressure across the segment if such is desired. The end seal is preferably constructed with a plane of symmetry such that the end seal is reversible and can be used in either side of a conventional splice case.

In accordance with one aspect of the invention, an end seal is provided for sealing the space between at least one cable and a closure. The end seal includes a centrally located support structure having a plurality of radially extending members, each member being defined by spaced, opposing end faces and an outer peripheral surface. Each of the radially extending members has first and second mating surfaces and a notch located in the first and second mating surfaces. The first and second mating surfaces are connected to, and extend between, the end faces of their respective radially extending members. The end seal also includes a plurality of segments having spaced, opposing end faces. The plurality of segments each interlock with the support structure so that each of the end faces of the segments extend in a common plane with one of the end faces of the support structure. Each segment includes an outer peripheral surface and first and second end surfaces connected to, and extending between, the end faces of the segment. The first and second end surfaces have first and second tabs, respectively, which extend therefrom. The first and second tabs are insertable in first and second notches, respectively, which notches are located in adjacent, radially extending members of the support structure. The first and second tabs of at least one segment are arranged so that they must be inserted in the first and second notches, respectively, in a prescribed sequence so that the segment interlocks with the support structure. At least one aperture

extends between the opposing end faces for receiving a cable. The aperture is formed, at least in part, from a semicylindrical surface located in one of the segments.

In some embodiments of the present invention, the apertures in the end seal are provided with a plurality of fingers which extend from the inner surface of the aperture to the interior thereof. The fingers are constructed (e.g., out of a semi-rigid plastic such as polyethylene) so that they are deformed when a cable is inserted into the aperture, thereby providing an initial seal between the cable and the end seal. This feature is especially useful in conjunction with expandable foams or gels which exhibit some tendency to flow, since the initial seal provided by the fingers helps to reduce such flow. In one particular embodiment, the fingers, when disposed in the aperture, have the appearance of a circle which is cut into a plurality of triangular sections, the tips of which sections meet at an interior point (e.g., the center) of the circle.

Brief Description of the Drawings

FIG. 1 shows an exemplary cable splice enclosure in which the inventive end seal may be employed;

FIG. 2 shows a perspective view of the segmented end seal in accordance with the principles of the present invention;

FIG. 3 shows a plan view of an end face of the end seal depicted in FIG. 2; and

FIGS. 4 and 5 show, respectively, an exploded perspective view and an exploded plan view of the segmented end seal shown in FIGS. 2 and 3.

Detailed Description

As shown in FIG. 1, an exemplary cable splice enclosure in which the inventive end seal may be employed comprises two semicylindrical half shells **70** and **72** that are joined together at flanges **74** by a suitable fastener. When the shells are joined together, they define opposing circular openings, each of which receive an end seal **10**. The circular openings each have a circumferential surface **76** that are extensions of the flanges. The circumferential surfaces contact the sealing surface **12** of the end seals. The flanges, including the peripheral surfaces, support an elastomeric gasket **78** to form a seal between the flanges of the two half shells themselves and between the half shells and the respective sealing surfaces of the end

seals. Of course, the end seal of the present invention may be used in many different types of splice cases and other closures and is not limited in applicability to the splice case depicted in FIG. 1. Moreover, the closure may employ only one end seal (such as in a closure for a butt-splice in which the cable only penetrates one end of the closure) or the closure may employ two end seals (such as in a closure for an in-line splice in which the cable penetrates both ends of the closure).

FIG. 2 shows a perspective view of the segmented end seal in its assembled state. The end seal includes a body defined by opposing end faces **21** (only one of which is visible in FIG. 2) and an outer sealing surface extending between the end faces. As indicated in FIG. 1, outer sealing surface contacts the outer circumferential surface of an end of the splice case to form a seal therebetween. Three apertures **25a**, **25b**, and **25c** extend through the body and between the end faces. Each aperture is configured to receive a cable that is to enter the splice case through the end seal. The components of the end seal shown in FIG. 2 are also shown in FIG. 3, which depicts a plan view of an end face of the end seal in its assembled state. The various components of the end seal will be further described below with reference to FIGS. 4 and 5.

FIGS. 4 and 5 show, respectively, an exploded perspective view and an exploded plan view of the segmented end seal shown in FIGS. 2 and 3. The end seal includes a support structure **20** and segments **22a**, **22b**, and **22c** that interlock with the support structure in the manner shown in FIG. 2 and 3 and described below. Segment **22a** has an outer surface portion **30a** that makes up a portion of the outer sealing surface shown in FIG. 2. Segment **22a** also has an inner semicylindrical surface **28a** and first and second mating surfaces **32a** and **34a**, which connect outer surface portion **30a** to inner semicylindrical surface **28a**. As shown, segments **22b** and **22c** are configured similar to segment **22a**. That is, segment **22b** includes an outer surface portion **30b** which forms a portion of the outer sealing surface, inner semi-cylindrical surface **28b**, and first and second mating surfaces **32b** and **34b**. Likewise, segment **22c** includes an outer surface portion **30c** which also forms a portion of the outer sealing surface, inner semi-cylindrical surface **28c**, and first and second mating surfaces **32c** and **34c**.

The support structure includes three members **40**, **42**, and **46** that extend radially outward from the center of the support structure. The support structure also includes outer semicylindrical surfaces **36a**, **36b**, and **36c**. The ends of semi-

cylindrical surface **36a** join with mating surfaces **24a** and **38a** of radially extending members **40** and **42**, respectively. Likewise, the ends of semicylindrical surface **36b** join with mating surfaces **38b** and **31a** of radially extending members **42** and **46**, respectively, while the ends of semicylindrical surface **36c** join with mating surfaces **31b** and **24b** of radially extending members **46** and **40**, respectively. The apertures **25** are defined by respective pairs of the inner semicylindrical surfaces **28** of segments **22** and outer semicylindrical surfaces **36** of the support structure. For example, aperture **25a** is defined by inner semicylindrical surface **28a** and outer semi-cylindrical surface **36a**.

As further shown in FIGS. 4 and 5, radially extending members **40**, **42** and **46** also respectively include outer surface portions **41**, **43**, and **47**, respectively, which, together with the outer surface portions of segments **22a**, **22b**, and **22c**, form the outer sealing surface of the end seal.

In its assembled state, segments **22a**, **22b**, and **22c** are joined to the support structure in the manner indicated in FIGS. 2 and 3. More specifically, with respect to segment **22a**, mating surface **32a** abuts mating surface **24a** of radially extending member **40** and mating surface **34a** abuts mating surface **38a** of radially extending member **42**. Similarly, with respect to segment **22b**, mating surface **34d** abuts mating surface **38b** of radially extending member **42** and mating surface **32b** abuts mating surface **31a** of radially extending member **46**. Finally, with respect to segment **22c**, mating surface **32c** abuts mating surface **24b** of radially extending member **40** and mating surface **34c** abuts mating surface **31b** of radially extending member **46**.

In accordance with the present invention, the mating surfaces of segments **22a**, **22b** and **22c** are each provided with pairs of tabs that are insertable in slots located in their corresponding mating surfaces of radially extending members **40**, **42**, and **46**. The tabs are arranged so that the segments interlock with the support structure only when the tabs are inserted into the slots in a particular sequence. For example, with respect to segment **22a** shown in FIG. 3, retaining tabs **39a** must be inserted into slots **54** prior to inserting locking tabs **37a** into slots **52**. The specific procedure that is employed so that segment **22a** properly interlocks with the support structure **20** is as follows. First, segment **22a** is oriented so that retaining tabs **39a** slide into slots **54**. Next, segment **22a** is pivoted about retaining tabs **39a** until locking tabs **37a** slide into slots **52** so that segment **22a** interlocks with the support structure. In other words, tabs **37a** and **39a** are oriented with respect to one another in such a way that the

segments cannot be installed in, or removed from, the support structure simply by radially displacing segment **22a** inward (when installing the segments) or outward (when removing the segments). Rather, segments **22a** must be pivoted into position in the previously described manner. This procedure is required because, as indicated in FIG. 5, retaining tabs **39a** are oriented so that the angle ϕ_1 formed between retaining tabs **39a** and the radially inward portion of mating surface **34a** is greater than the angle ϕ_2 formed between locking tabs **37a** and the radially inward portion of mating surface **32a**. As depicted in the figures, the angle ϕ_1 will generally be an obtuse angle.

The specific values for the angles ϕ_1 and ϕ_2 can vary somewhat, and can be manipulated to produce a desired pressure distribution across segment **22a**. In particular, these angles can be manipulated to produce a greater pressure on one end of the segment or the other, or to produce an essentially equal pressure distribution across the segment. However, ϕ_2 is preferably within the range $\pm 20°$ from normality, more preferably within the range $\pm 6°$ to $\pm 18°$ from normality, and most preferably is about $\pm 12°$ from normality. The optimum value for ϕ_1, when ϕ_2 is about 112°, is about 221°. When ϕ_1 has this value, tab **39a** slides smoothly in a sideward motion (from tab **39a** to tab **37a**) into its locking position as force is applied (e.g., via bolt **62**) to drive tab **37a** into slot **52**. When ϕ_1 deviates too far from these values, tab **39a** may not engage slot **52** as smoothly, and/or may exhibit an increased tendency to pop out of slot **52**. Of course, one skilled in the art will appreciate that the optimum values for these angles may be affected by the particular application to which the device is directed, the desired pressure distribution across the segment, the materials out of which the segment is made, the dimensions of tab, and other such factors.

While not described in detail, segments **22b** and **22c** have locking and retaining tabs that function in the same manner as described with respect to segment **22a**.

As previously mentioned, the procedure used for interlocking segments **22a**, **22b**, and **22c** with the support structure can only be accomplished by inserting their respective tabs into their corresponding slots in the correct sequence. If the sequence is reversed so that, for example, locking tabs **37a** of segment **22a** are inserted prior to retaining tabs **39a**, then when segment **22a** is pivoted about tabs **37a**, tabs **39a** will not be accepted by slots **52**. Moreover, the segments **22a**, **22b**, and **22c** can only be

removed from the support structure by reversing the installation procedure so that the tabs are removed from the slots in the reverse sequence (i.e., the second pair of tabs inserted in their corresponding slots is the first pair removed). That is, segment **22a** is removed by first pivoting it outward so that locking tabs **37a** are removed from slots **52**. Once tabs **37a** are removed, retaining tabs **39a** may be slid out of slots **54**. However, segment **22a** will remain interlocked with support structure if an attempt is made to remove retaining tabs **39a** prior to locking tabs **37a**.

Because of the particular arrangement of the tabs, segments **22a**, **22b**, and **22c** each may be fastened to the support structure with only a single fastener. This may be accomplished with respect to segment **22a**, for example, by inserting a bolt **62** or other fastener through mating surfaces **32a** and **24a**, as indicated in FIGS. 4 and 5. As a result, locking tabs **37a** cannot be removed from slots **52** without first removing the fastener. Since tabs **37a** cannot be removed, retaining tabs **39a** cannot be removed as well. Accordingly, as long as locking tabs **37a** are fastened into position, there is no need to additionally fasten tabs **37a** into position. In other words, a single fastener is sufficient to lock segment **22a** into place so that it cannot be removed.

Although various embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and are within the purview of the appended claims without departing from the spirit and intended scope of the invention. For example, the shape of the end seal need not be round, but may have any shape (e.g., oval) which is necessary to conform to the end of the splice case or other closure in which it is to be located. Additionally, the end seal may include any number of segments (but at least two) and is thus not limited to the three segments shown in the embodiment depicted in the figures. Likewise, the number of cable-receiving apertures may vary from end seal to end seal and even from segment to segment. In this regard, one of ordinary skill in the art will recognize that the apertures need not be formed in both the segments and the support structure. Rather, one or more of the apertures may be located entirely within a single segment. In fact, in some embodiments of the invention, all of the apertures may be entirely formed in the various segments so that the support structure is free of any surfaces that directly mate with a cable. The end seals of the present invention may also be provided with ribs where appropriate to increase the strength of the end seal, and holes or indentations to conserve materials and reduce weight.

What is claimed is:

1. An end seal for sealing the space between at least one cable and a closure, comprising:

a centrally located support structure having a plurality of radially extending members each defined by spaced, opposing end faces and an outer peripheral surface, each of the members having first and second mating surfaces and a notch located in the first and second mating surfaces, said first and second mating surfaces connected to and extending between the end faces of the respective radially extending members;

a plurality of segments having spaced, opposing end faces, the plurality of segments each interlocking with the support structure so that each of the end faces of the segments extend in a common plane with one of the end faces of the support structure, each of the segments including an outer peripheral surface and first and second end surfaces connected to and extending between the end faces of the respective segment, said first and second end surfaces having first and second tabs extending therefrom, respectively, said first and second tabs being insertable in first and second ones of the notches respectively located in adjacent ones of the radially extending members of the support structure, wherein the first and second tabs of at least one segment are arranged so that they must be inserted in the first and second notches, respectively, in a prescribed sequence so that the segment interlocks with the support structure; and

at least one aperture extending between the opposing end faces for receiving a cable, said aperture being formed, at least in part, from a semicylindrical surface located in one of the plurality of segments.

2. The end seal of claim 1, wherein the first and second mating surfaces of the radially extending members each include a pair of notches and the first and second end surfaces of the segments each include a pair of first and second tabs, respectively.

3. The end seal of claim 1, wherein the aperture is formed from a semicylindrical surface located entirely in one of the segments.

4. The end seal of claim 1, wherein the aperture is formed from first and second semicylindrical surfaces respectively located in one of the segments and the support structure.

5. The end seal of claim 1, wherein the segments and the support structure are shaped so that in an assembled state the end seal has a circular cross-sectional shape.

6. The end seal of claim 1, wherein the plurality of segments comprise three segments and the at least one aperture includes three apertures, wherein each of the apertures is formed from first and second semicylindrical surfaces respectively located in the support structure and a different one of the segments.

7. The end seal of claim 1, wherein the first and second tabs of a given segment form first and second angles, respectively, with the end surfaces of the given segment, said first angle being greater than the second angle.

8. The end seal of claim 7, wherein the first angle is an obtuse angle.

9. The end seal of claim 8, wherein the given segment interlocks with the support structure by inserting the first tab into the first notch before the second tab is inserted into the second notch.

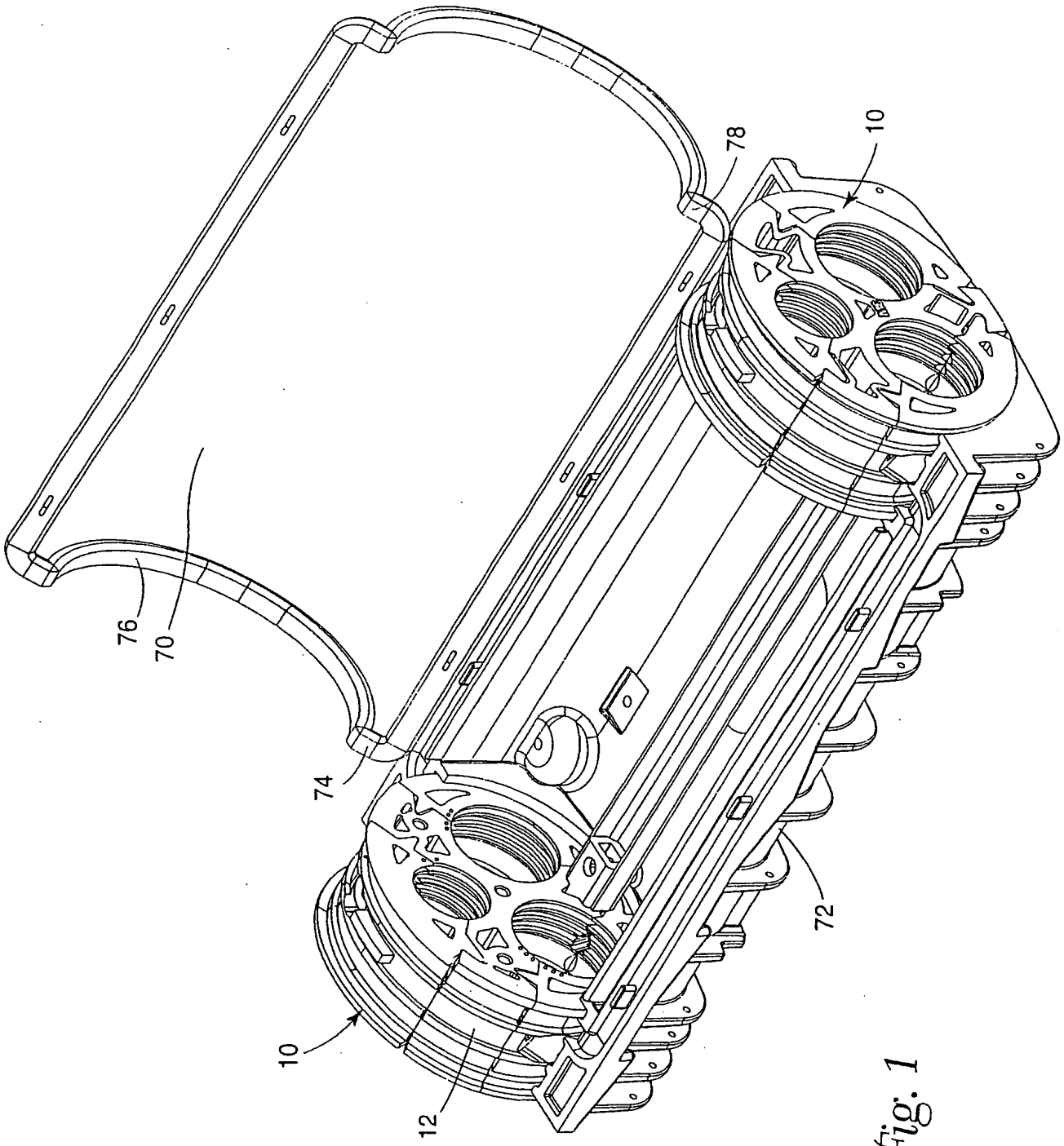


Fig. 1

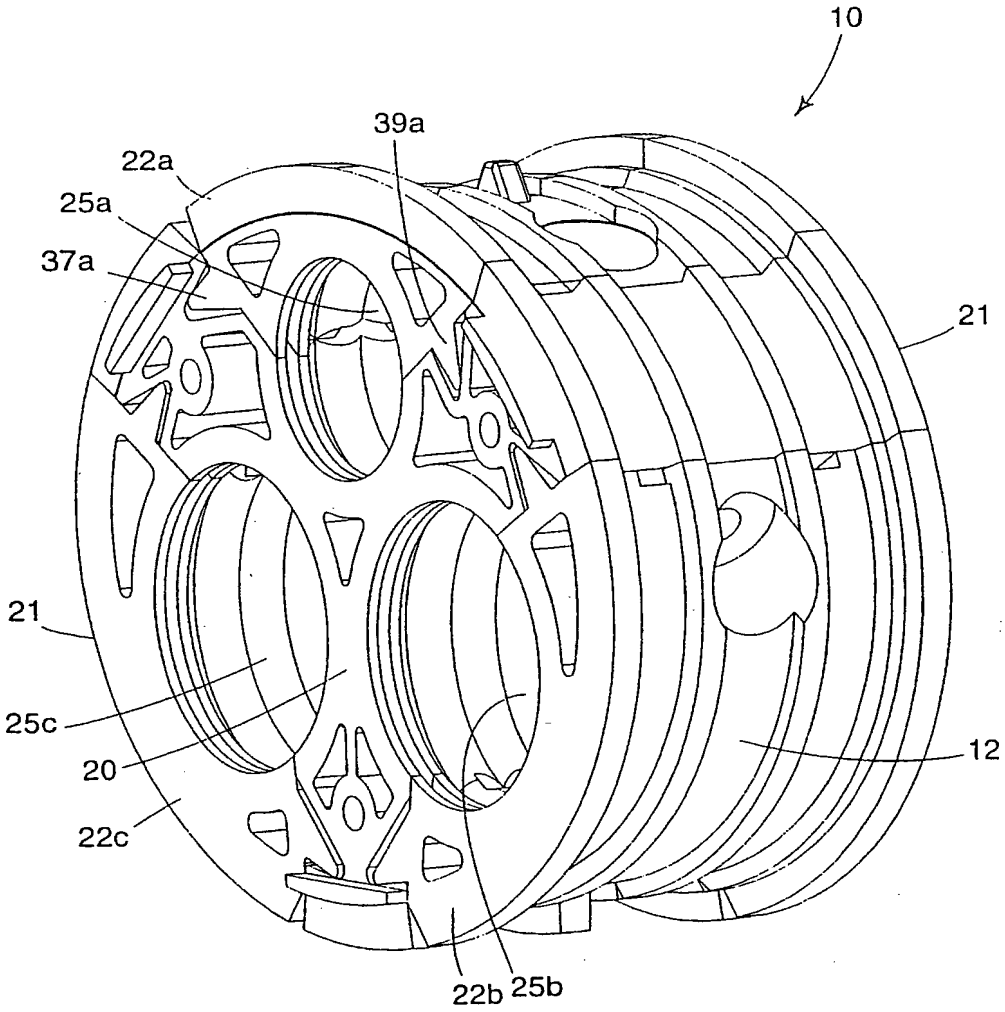
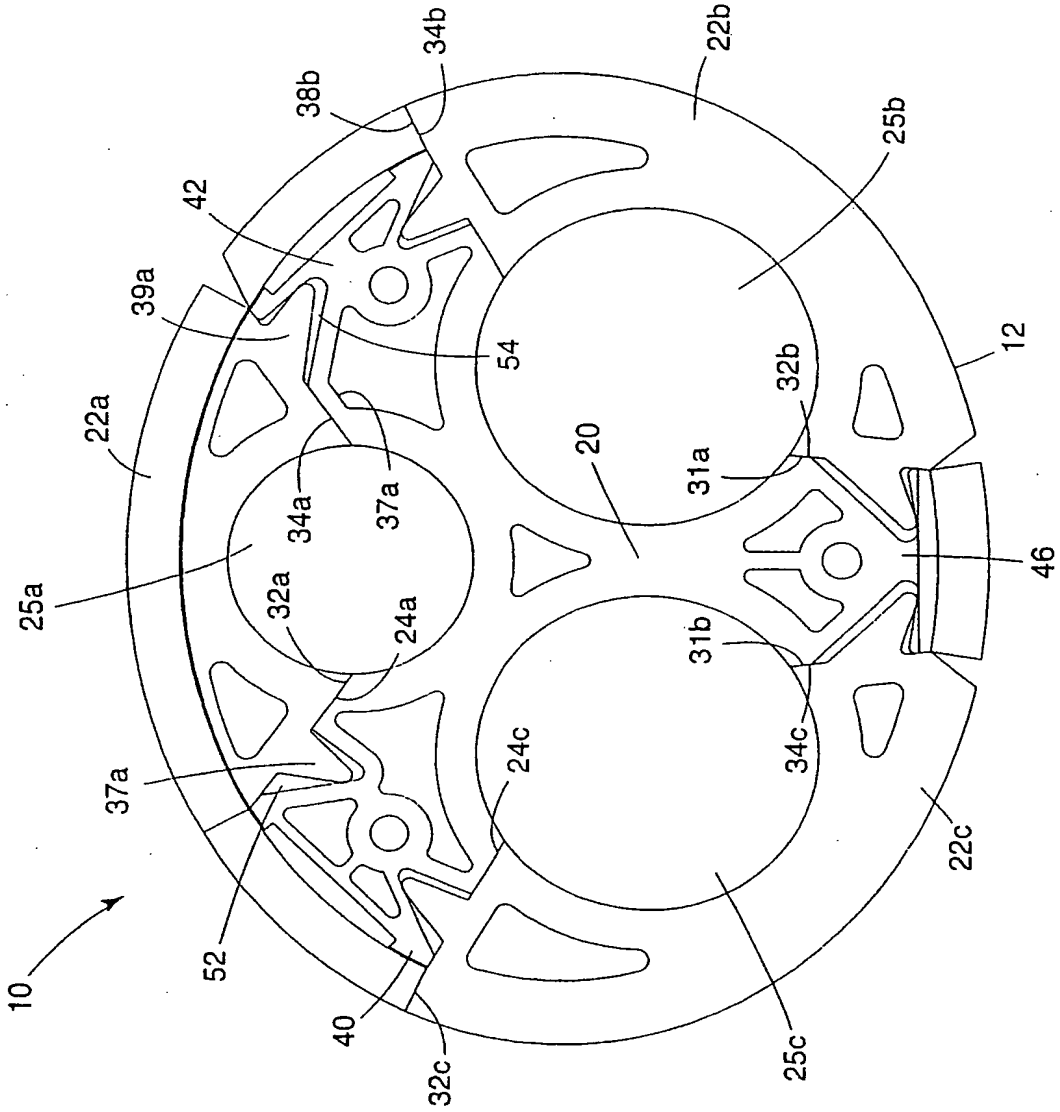


Fig. 2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22b
22c
24a
24c
25a
25b
25c
31a
31b
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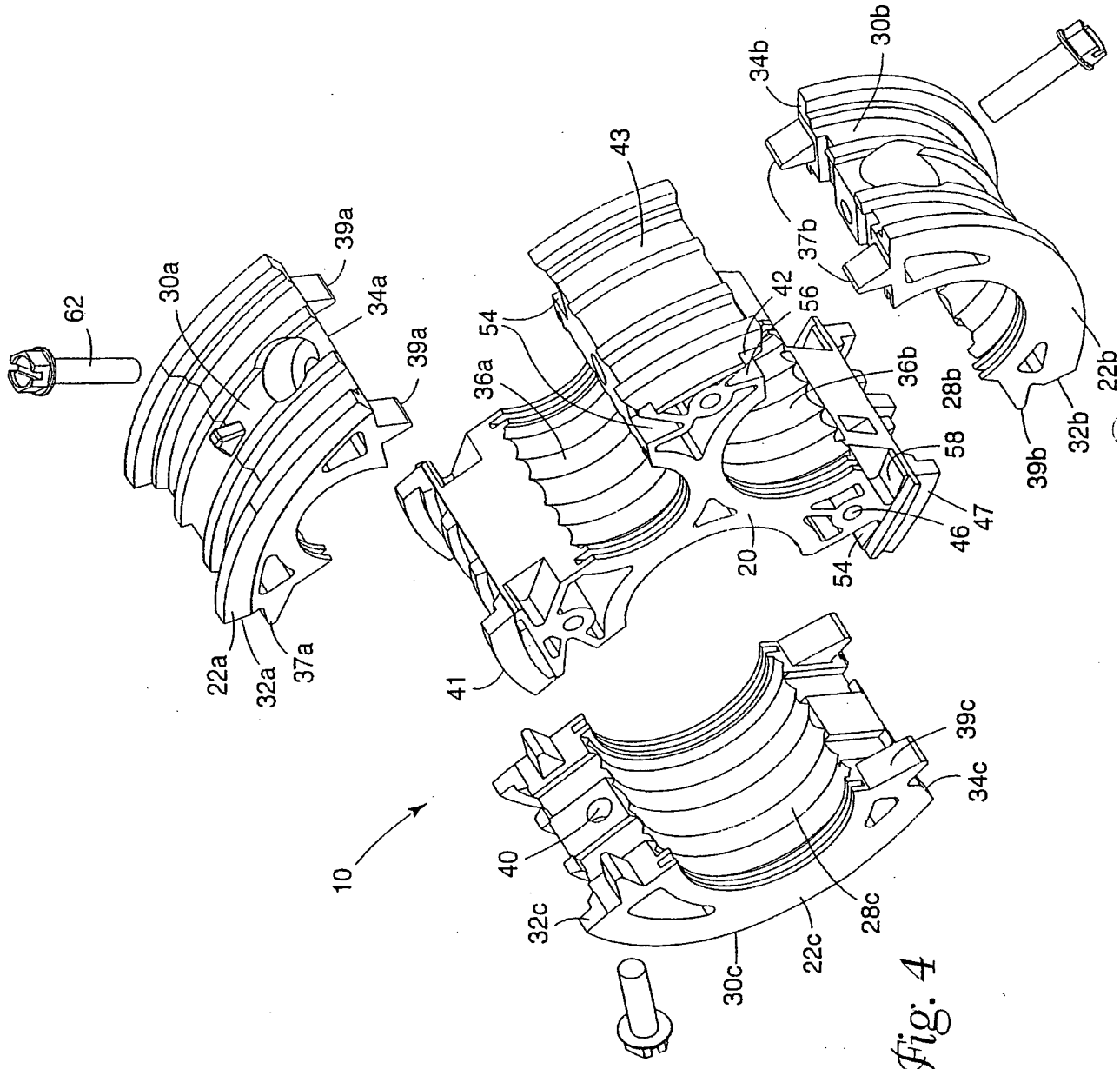
38b
39a
40
42
46
52
54

Fig. 3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39a
22a
32a
37a
41
43
54
36a
42
56
36b
28b
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46
20
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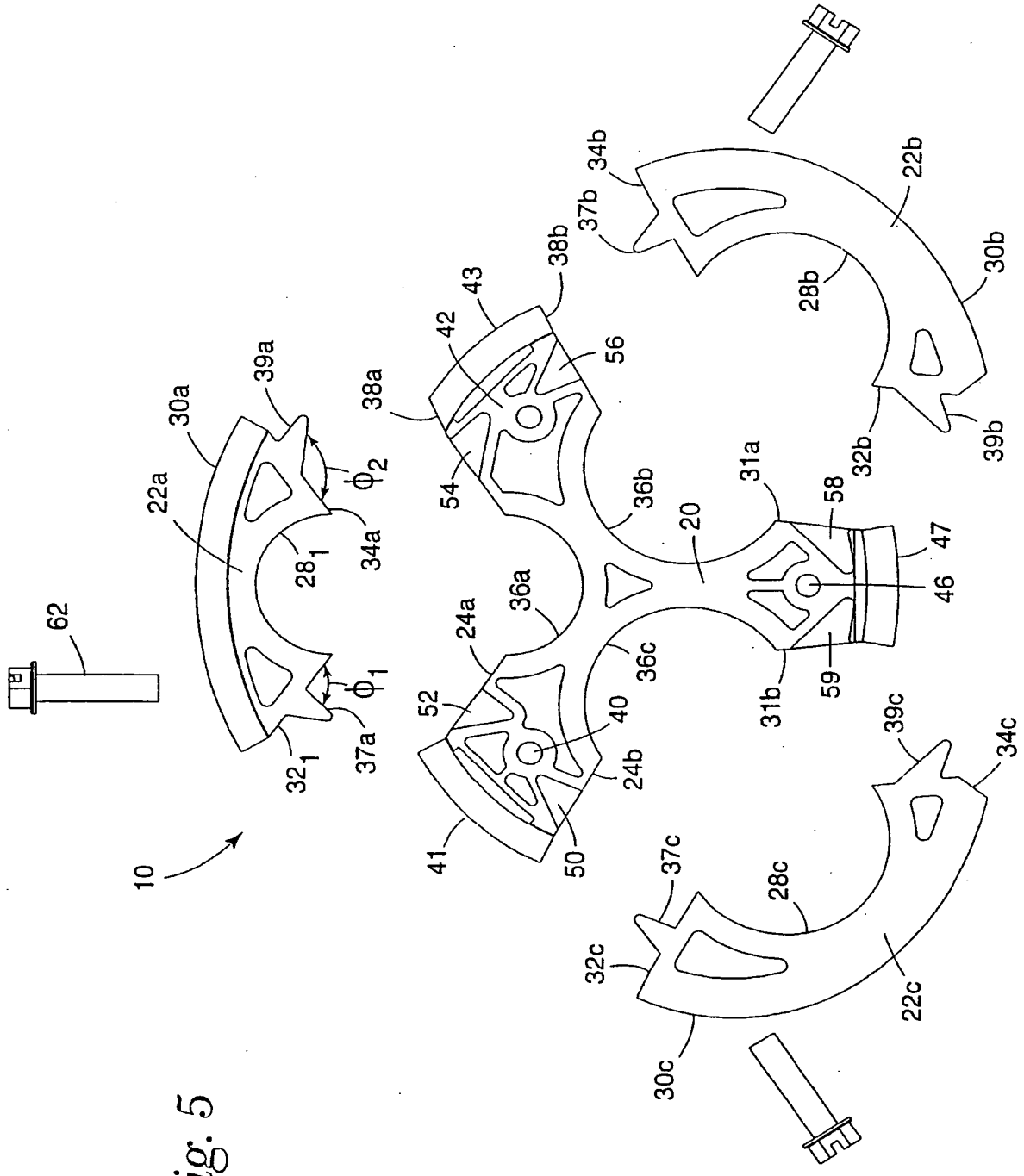
40
32c
28c
22c
30c
10

Fig. 4


62
10
22a
30a
39a
38a
ϕ_2
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42
43
38b
56
36b
20
31a
58
47
46
59
31b
36a
24a
52
40
24b
41
50
36c
37b
34b
22b
28b
30b
32b
39b
39c
34c
37c
28c
32c
22c
30c

Fig. 5

INTERNATIONAL SEARCH REPORT

national Application No
PCT/US 00/01872

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02G15/013

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02G G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 21799 A (MINNESOTA MINING & MFG) 22 May 1998 (1998-05-22) page 5, line 11 -page 6, line 13; claim 1; figures 1,2 ---	1,3-6
A	US 4 692 565 A (KOHT LOWELL ET AL) 8 September 1987 (1987-09-08) cited in the application column 2, line 39 -column 3, line 34; figures 1,2 ---	1,3-6
A	US 5 059 748 A (ALLEN BARRY ET AL) 22 October 1991 (1991-10-22) figures 1,3 --- -/--	1,3-6

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2000	30/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lommel, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 825 961 A (WILKINS TIMOTHY A ET AL) 20 October 1998 (1998-10-20) cited in the application column 8, line 28 - line 67; figures 1,2	1,3-6
A	FR 818 334 A (GEOFFROY-DELORE) 24 September 1937 (1937-09-24) figures 12,15	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

rnational Application No
PCT/US 00/01872

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9821799 A	22-05-1998	AU 2326197 A	03-06-1998
US 4692565 A	08-09-1987	CA 1273418 A	28-08-1990
		EP 0232180 A	12-08-1987
		JP 62185511 A	13-08-1987
US 5059748 A	22-10-1991	NONE	
US 5825961 A	20-10-1998	US 5568584 A	22-10-1996
		AU 7077996 A	17-04-1997
		CN 1202969 A	23-12-1998
		EP 0871909 A	21-10-1998
		WO 9712268 A	03-04-1997
		US 5793920 A	11-08-1998
		US 5793921 A	11-08-1998
		US 5835658 A	10-11-1998
FR 818334 A	24-09-1937	NONE	